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Recommended Remedial Measures at Naval Warfare Center Crane (NSWCC), Dye Burial Ground (DBG) Solid Waste Management Unit (SWMU) 02/11

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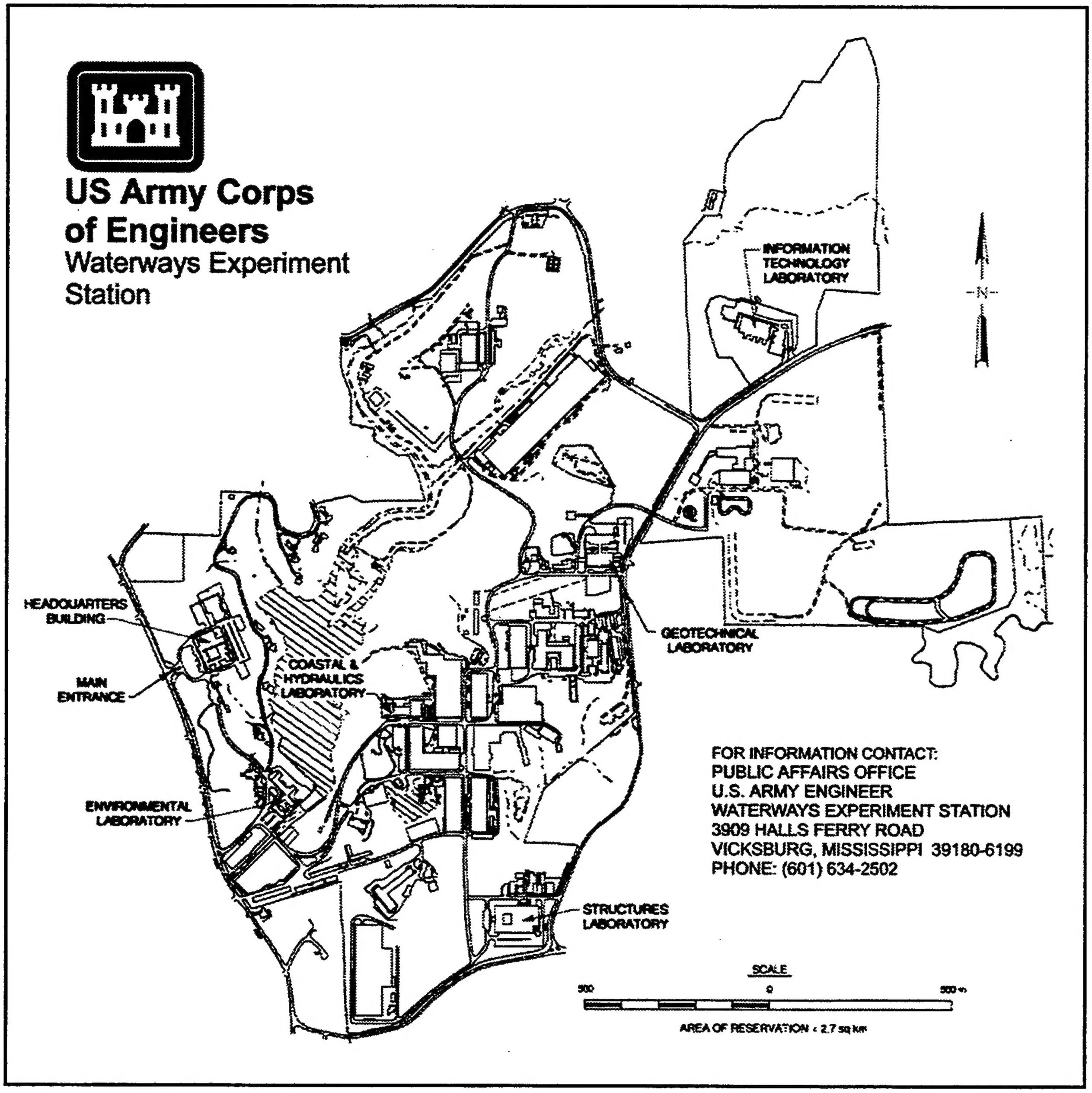
Prepared for Naval Surface Warfare Center Crane



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Preface

This report describes recommendations for remedial measures at Naval Surface Warfare Center Crane (NSWCC), Dye Burial Ground (DBG) SWMU 02/11. This work is a product of the Installation Restoration (IR) program designed to identify contamination of Navy lands resulting from past operations and to institute corrective measures, as needed. Development of this report was funded by the NSWCC. Mr. David Bennett, Soil and Rock Mechanics Division, Geotechnical Laboratory (GL), U.S. Army Engineer Waterways Experiment Station (WES), was the principal investigator and Mr. William Murphy, Hydrogeology and Site Characterization Section, GL, WES, was the program manager.

This report was prepared in GL by Ms. M. Eileen Glynn, Rock Mechanics Branch, Mr. Bennett, Acting Chief, Soil and Rock Mechanics Division, and Dr. Timothy D. Stark, Civil Engineering Department, University of Illinois. The work was performed under the general supervision of Dr. William F. Marcuson III, Director, GL.

At the time of publication of this report, the Director of WES was Dr. Robert W. Whalin. The Commander was COL Robin R. Cababa, EN.

Acronyms

BS	Barrier Soil
CL	Silty Clay (Unified Soil Classification System)
C_r	consolidation constant
cu	cubic
DBG	Dye Burial Ground
EPA	United States Environmental Protection Agency
FML	Flexible (geo) Membrane Liner
ft	foot or feet
gal	gallon(s)
GCL	Geosynthetic Clay Layer
H	height of soil
HDPE	High Density Polyethylene
HELP	Hydrologic Evaluation Landfill Performance Model
IAS	Initial Assessment Study
in.	inch(es)
IR	Installation Restoration
K	hydraulic conductivity
lb	pound(s)
LD	Lateral Drainage
mil	millionth inch
NOAA	National Oceanic and Atmospheric Administration
NSWCC	Naval Surface Warfare Center Crane
PVC	polyvinyl chloride
QA/QC	Quality Assurance/Quality Control
RCRA	Resource Conservation and Recovery Act

RI	Remedial Investigation
S	settlement
SWMU	Solid Waste Management Unit
T_v	Terzaghi Time Factor
t_x	time (days)
U	percent consolidation
VP	Vertical Percolation
WES	Waterways Experiment Station
w_{opt}	optimum water content
γ_d	dry unit weight

Conversion Factors, Non-SI to SI Units of Measurement

Non-SI units of measurement used in this report can be converted to SI units as follows:

Multiply	By	To Obtain
acres	4,047	square meters
cubic feet	0.2832	cubic meters
cubic yards	0.7646	cubic meters
feet	0.3048	meters
feet/day	0.0000294	centimeters/second
gallons	3.785	liters
inches	2.54	centimeters
mil (millionth inch)	0.00254	centimeters
pounds	0.4536	kilograms
pounds/cubic feet	16.2	kilograms/cubic meter

Introduction

The following recommendations for remedial measures at the Naval Surface Warfare Center Crane (NSWCC), Dye Burial Ground (DBG), are provided as partial fulfillment of the Draft Work Plan for Remedial Actions, NSWCC (INS 170 023 498, dated 31 July 1994) and subsequent revisions to this work plan (dated February 1995). These recommendations satisfy all objectives and requirements for the DBG set forth by letter of 30 September 1993 from Mr. G. K. Hill, Deputy Director, Public Works Department, NSWCC, to Ms. Carol Witt-Smith, EPA, Region V.

Background on DBG

The location of NSWCC is shown in Figure 1. An initial assessment study (IAS) was conducted at the Crane Naval Weapons Support Center, later renamed Naval Surface Warfare Center Crane (NSWCC), in 1981 to identify and assess sites of potential threats to health or the environment by contamination from past hazardous materials operations (Eakes 1983). The DBG is located in Section 21, T5N, R3W and is one of fourteen sites identified as warranting further assessment by a Remedial Investigation (RI). The RI and the IAS are part of the Installation Restoration (IR) program designed to identify contamination of Navy lands resulting from past operations and to institute corrective measures, as needed. The DBG is in the eastern part of the NSWCC, just east of the Ammunition Burning Ground (Figure 2), and sits atop a northeast trending ridge.

Early Investigations

The IAS team reported that an estimated 50,000 lb of various dyes and dye-contaminated materials were deposited into three open trenches at the DBG from 1952 until 1964. These trenches were each about 10 ft wide, 6 ft deep and 50 ft long. Deposited materials included magnesium, boxes and rags contaminated with dyes and approximately 60 drums of dyes. The trenches were reportedly backfilled to ground surface with soil in 1972, but were not permanently capped.

Investigations by Waterways Experiment Station (WES) personnel at selected sites provided further information on conditions at the DBG. Eight exploratory borings and wells were placed near the dye burial area to depths as great as 70 ft (Dunbar 1982). The eight wells provided preliminary data on water table elevations and direction of ground water flow in the uppermost aquifer. The surface soil at the DBG was classified in the laboratory as a lean silty clay (CL) (Unified Soil Classification System, USCS) and data from these borings are summarized in Table 1. Additional monitoring wells were installed in 1987-1988. The monitoring wells emplaced around the trench area indicate that the uppermost ground water (phreatic) zone is 12 to 20 ft below the ground surface, or approximately 6 to 14 ft below the suspected base of the trenches (as reported in the IAS, Eakes 1983). A geologic cross section of the DBG showing the general location of the trenches is presented in Figure 3. The

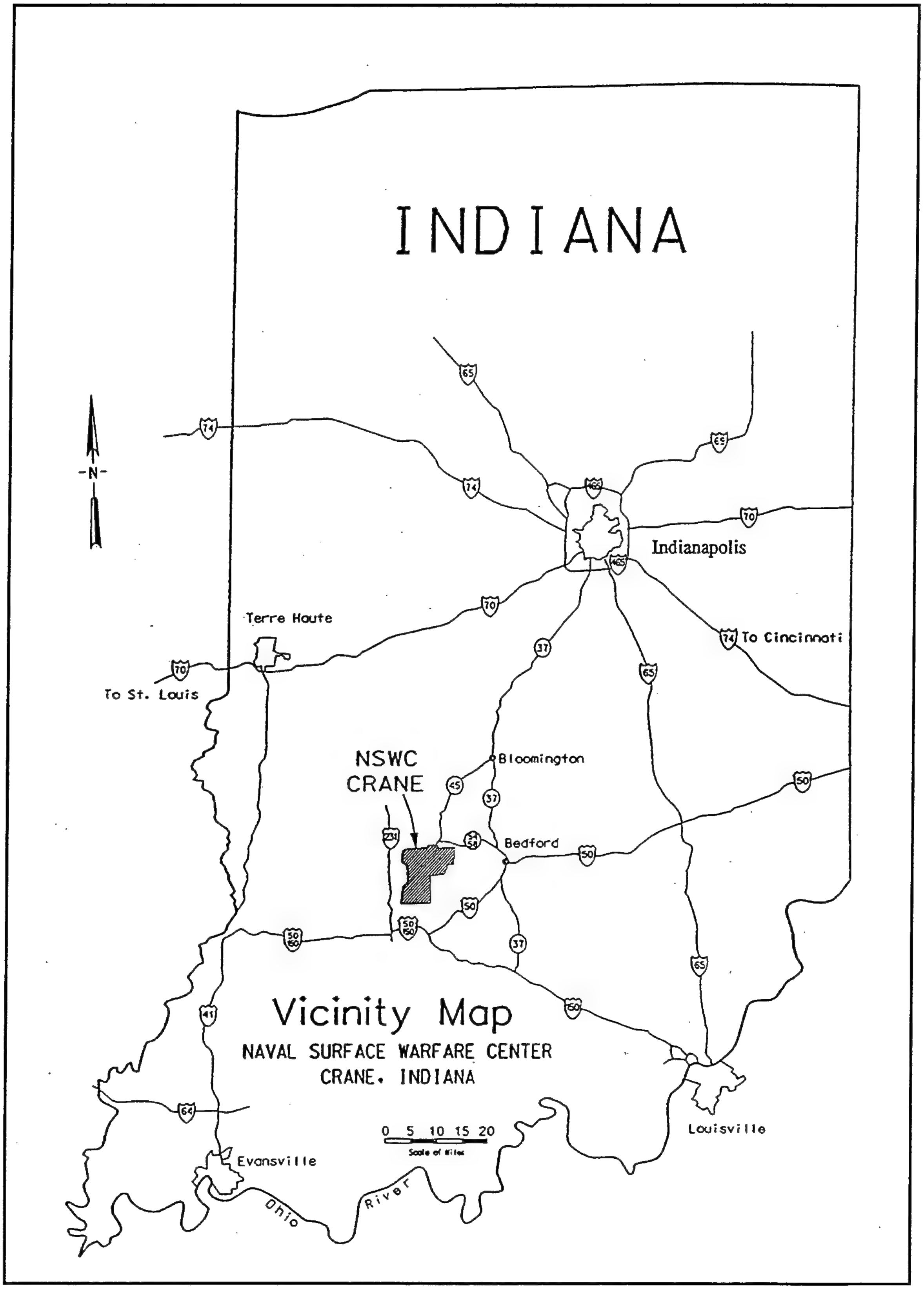

Figure 1. Location of NSWCC, Indiana (from Murphy and Wade 1994)

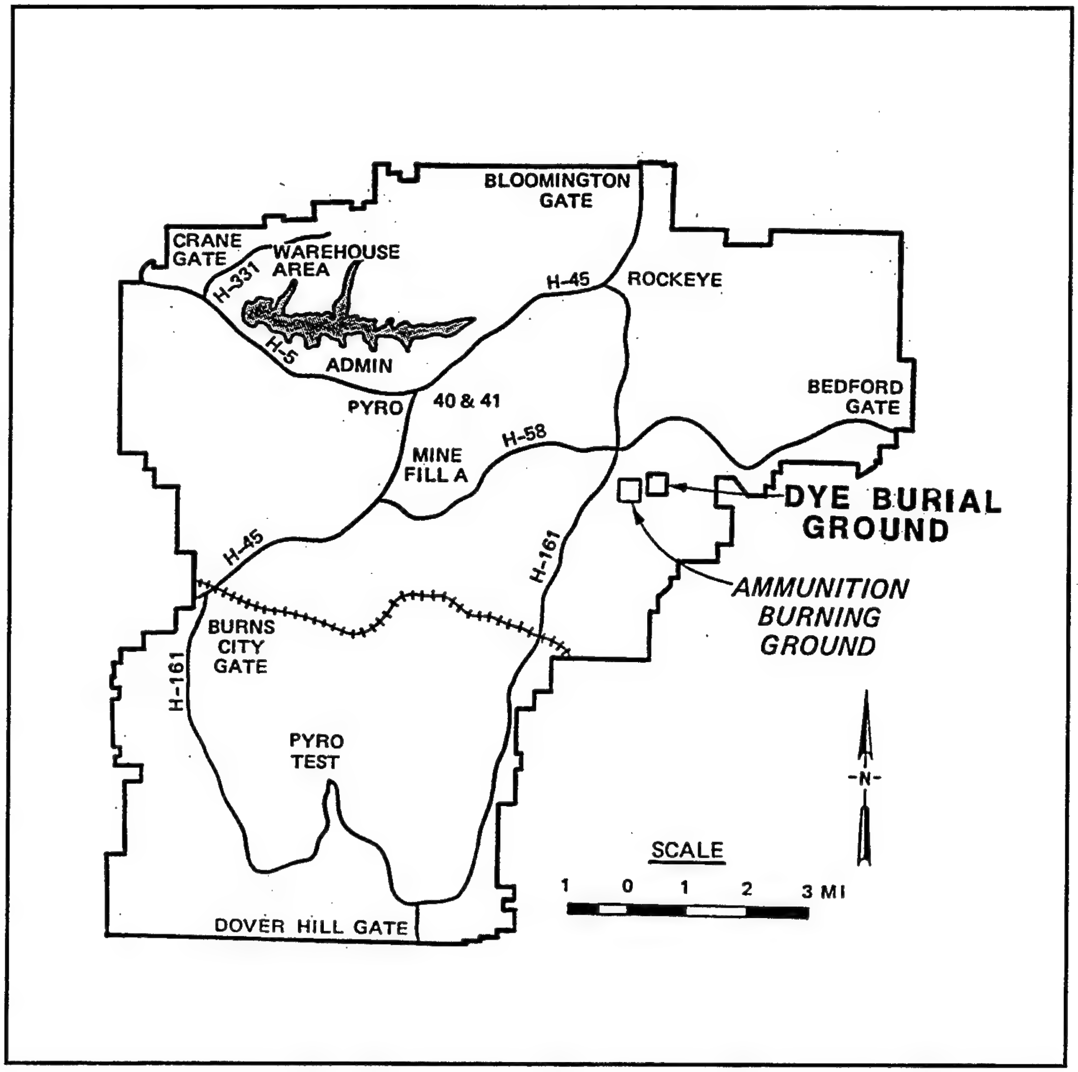

Figure 2. Location of the Dye Burial Ground (DBG) (from Murphy and Wade 1994)

trenches are on a topographic high, that is relatively flat and can pond precipitation during wet seasons. The bottoms of the trenches are expected to be in either soil or weathered rock. None of the mentioned monitoring wells penetrated trench fill material, or have intersected dye contaminated groundwater.

As mentioned, general soil conditions in the area of the site have been summarized by Dunbar (1982) (Table 1), as lean silty clay (CL) from the ground surface to the top of rock based on the 8 well borings. Top of rock ranges from 6 to 10 ft below ground surface, as determined by refusal of a split spoon sampler (Dunbar 1982). Geologic logs of monitoring well borings indicate soils are silty clay to silty sands from 5 to 10 ft depths in the DBG area (Murphy and Wade 1994).

Table 1
Laboratory Soil Test Results, Eight Deep Borings Made in 1981 (Dunbar 1982)

Boring Number	Sample Number	Depth (ft)	Dry Density (lb/cu ft)	Water Content (percent)	Liquid Limit (percent)	Plastic Limit (percent)	Plasticity Index (percent)	USCS	Hydraulic Conductivity (ft/day)	Cation Exchange Capacity (meq/100 g)
2-1-81	1	0.9-1.9	101.0	21.9	38	19	19	CL		7.83
2-1-81	2	6.0-7.0	125.1	11.1	25	14	11	CL		
2-2-81	1	0.0-1.7	93.3	21.2	46	21	25	CL	1.01×10^{-2}	2.54
2-3-81	1	0.0-1.2	108.9	18.4	44	23	21	CL		4.49
2-3-81	2A[1]	5.0-5.7	---	14.3	38	14	24	CL		
2-4-81	1	0.0-2.2	91.4	18.5	42	21	21	CL		2.81
2-5-81	1	0.0-1.6	93.8	18.0	44	23	21	CL		4.51
2-5-81	2	5.0-6.1	117.0	8.8	25	14	11	CL		
2-6-81	1	0.0-2.2	82.7	15.8	31	17	14	CL		
2-6-81	2	5.0-6.3	106.3	15.4	38	15	23	CL	1.31×10^{-0}	0.49
2-7-81	1	0.0-2.0	105.5	9.2	34	15	19	CL		5.06
2-8-81	1	0.0-2.3	84.8	17.1	39	18	21	CL		
2-8-81	2	5.0-6.7	117.0	13.4	39	16	23	CL	2.0×10^{-3}	6.38

[1] Jar sample.

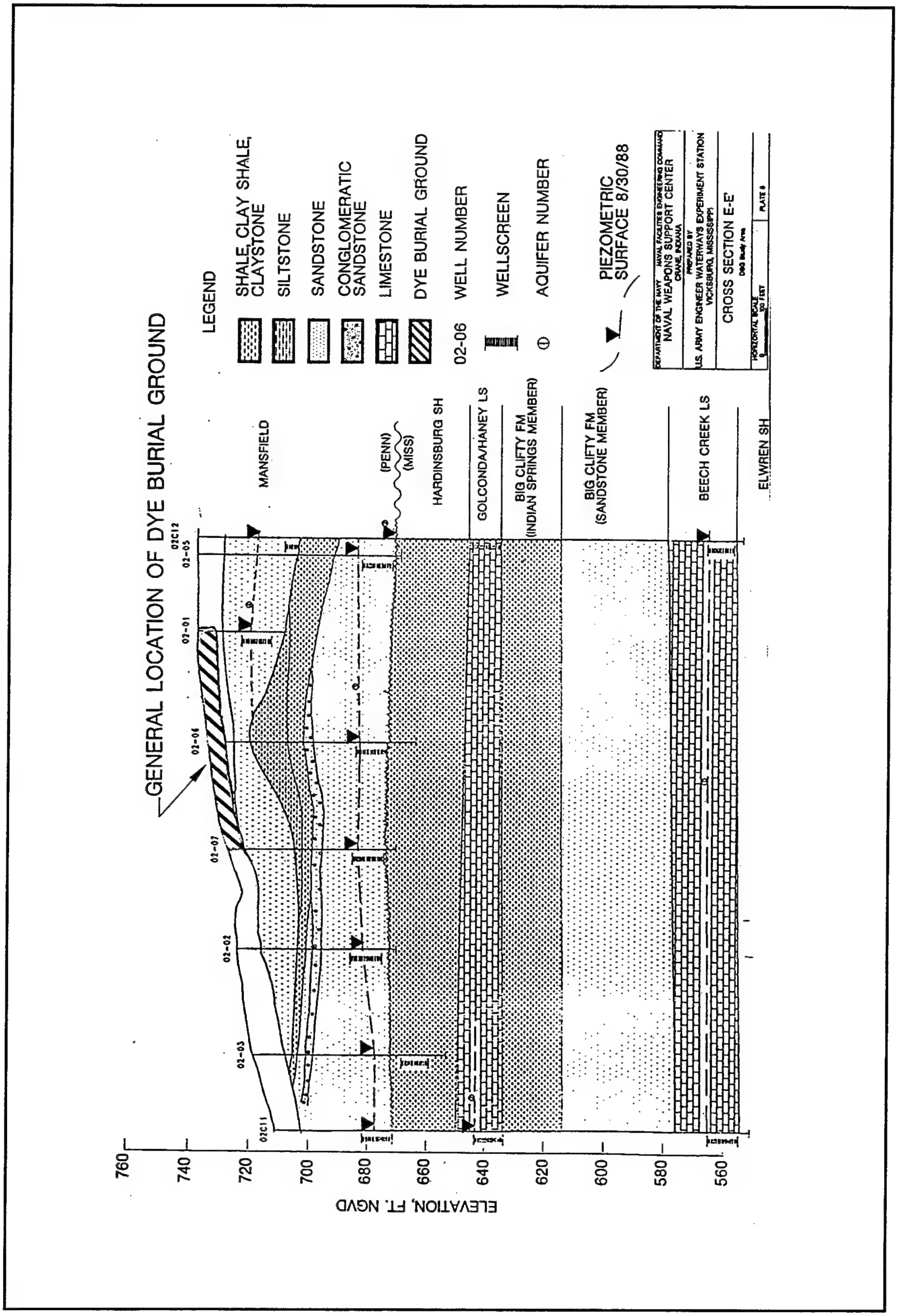

Figure 3. Geologic cross section at DBG (looking northwest)

Recent Investigations

Reconnaissance surveys by WES in October through November 1994 and March 1995, provided additional information about soils in the immediate vicinity of the DBG and more closely defined the trench boundaries. These surveys confirmed that the undisturbed (in situ) soils surrounding the trenches were generally medium to stiff to hard, moist to almost dry, silt and silty clay. Four auger borings made in November 1994 confirmed depth to weathered rock adjacent to the trenches as 6.5 to 8.0 ft. Logs of the November 1994 borings are provided in Appendix A.

The soils overlying the apparent trench locations are generally brown to gray, very soft to soft, silty clay and could only be visually inspected (no samples were taken from the trenches). Shallow puddles of standing water, approximately 6 in. deep were observed in 2 locations. The smallest of these puddles, approximately 2 ft in diameter, is believed to be southwest of the DBG trenches. The other puddle approximately 3 ft wide by 10 ft long covered part of what is thought to be the northern end of trench 3, the southernmost trench. Cattails were present in this location, suggesting that wet soil conditions have existed for some time at this site. Monkey grass, caney vegetation, and other vegetation generally associated with wet soil conditions were observed in 2 other locations, further north of trench 3. No other instances of puddles or standing water were evident.

Detail Description of Site Topography

The local site topography of the site is generally flat (Figure 4) although the surrounding topography is steep. The surfaces of the trenches are level with or slightly below (0.5 to 1 ft) the surrounding undisturbed ground. A low narrow berm or ridge that appears to be man-made, rises from west to east along the southern perimeter of the trenches. This berm has a maximum height of approximately 5 ft and may be the original soil excavated from the trenches. Young trees, from 1 in. saplings to 12 to 18 in. diameter or larger trees flank the boundaries of the trenches, except for the northern edge. A site access road borders the north side of the trenches. Locations and sizes of trees expected to interfere with construction are presented on Figure 5 were surveyed and are summarized in Table 2. The access road, shown on Figure 5, will require relocation northward to allow room for cover construction.

In summary, the boundaries of the 3 individual dye burial trenches have been determined through review of available information, reconnaissance surveys, and geophysical surveys (Murphy 1994) to sufficient accuracy to permit design and construction of an interim cover. The approximate boundaries are shown in Figure 5, along with locations of nearby monitoring wells and other landmarks.

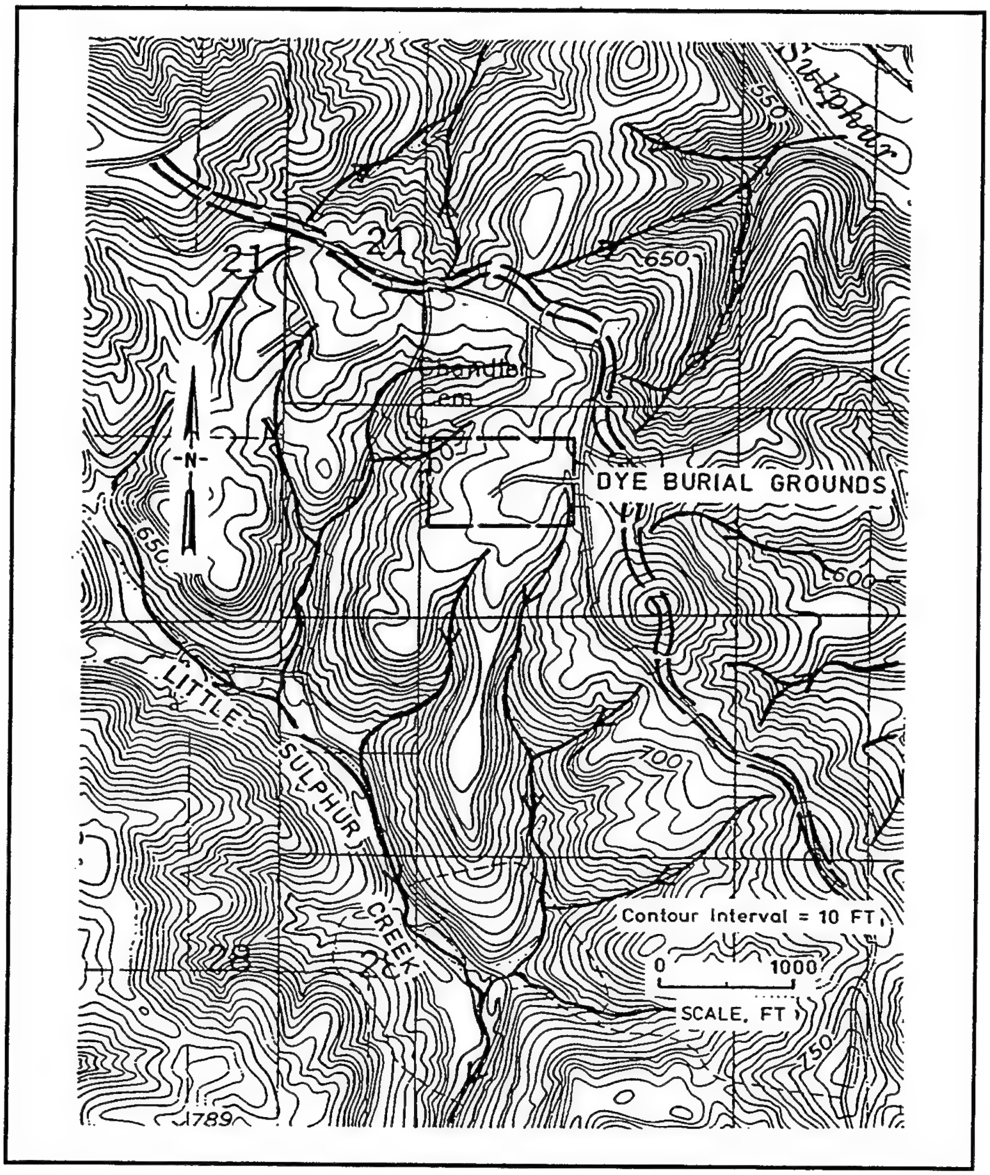

Figure 4. Contour and drainage map showing DBG (Murphy and Wade 1994)

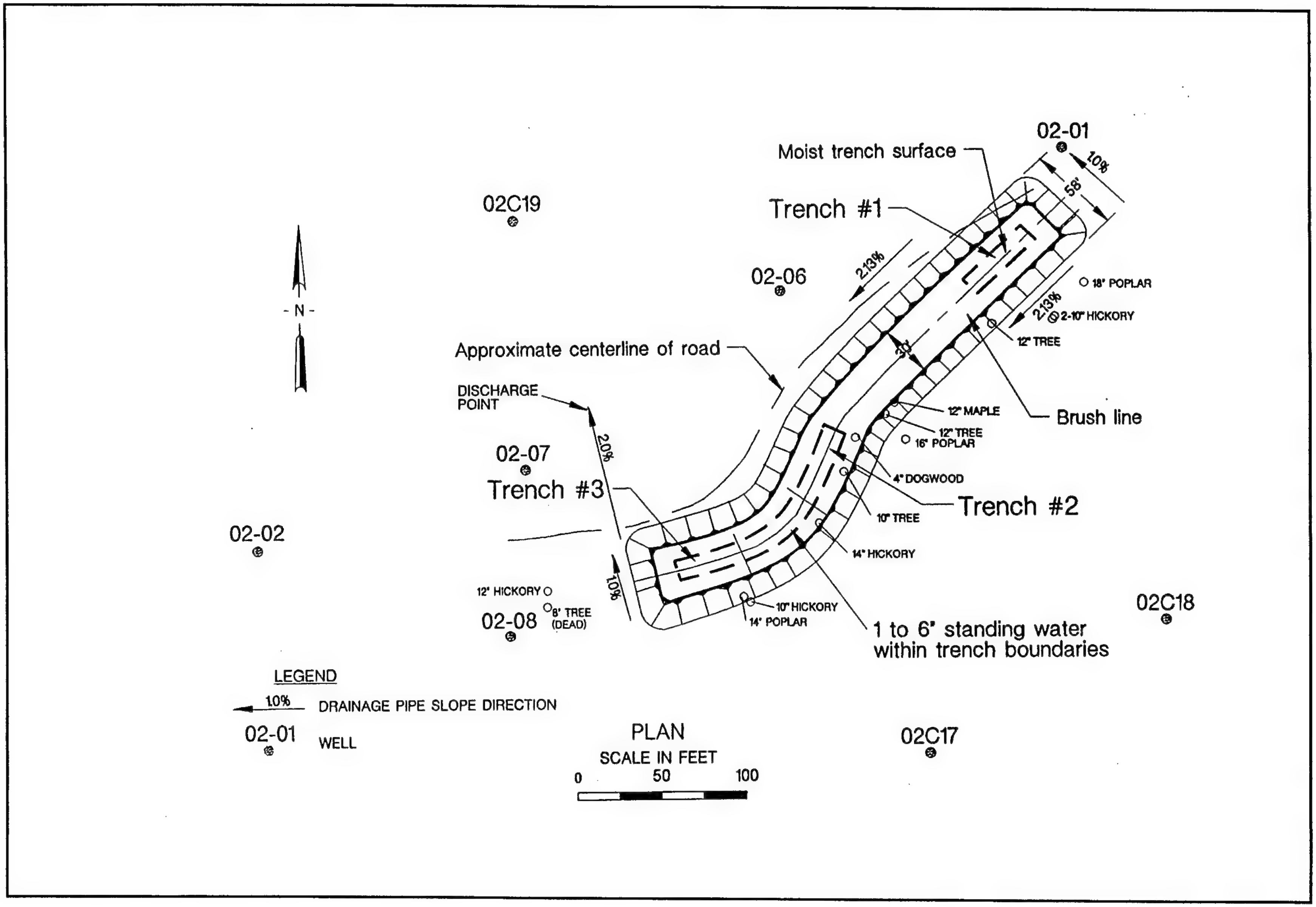

Figure 5. Plan view of cover design for DBG Crane, Indiana

Table 2
Approximate Locations, Sizes, and Number of Trees Adjacent to DBG Trenches to be Removed Prior to Construction of Cover

	Tree Sizes and Numbers		
	3" < Diameter < 8"	8" < Diameter < 18"	Diameter > 18"
SE of Trench #1	8	---	1
SE between Trench #1 and #2	27	---	---
SE of Trench #2	11	4	---
SE between #2 and #3	---	---	---
SE of Trench #3	9	3	---
North of Trench #1 and between Wells #02-06 and #02-01	53	10	7
Estimated total number of trees to be removed	108	17	8

Note: Tree diameter measured at approximately 2-3 ft above ground.

Rationale and Approach for DBG Remedial Measures Recommendations

The original draft work plan submitted by WES in July 1994, based partly on the internal WES cost estimate for DBG, dated 16 November 1993, envisioned design and construction of a "Resource Conservation and Recovery Act (RCRA) equivalent" cover as an interim remediation measure at DBG. A "RCRA equivalent" cover, designed and constructed as an interim remedial measure would offer a high level of protection to human health and the environment. Also, regulatory approval would be more easily obtainable for a "RCRA equivalent" cover design, than for alternative recommendations with less extensive performance documentation histories. Finally, the interim cover would have a high probability of successfully being approved and incorporated into the long-term remedial measures for the DBG.

This "RCRA equivalent" approach remains as the most viable option, after extensive consideration and analyses of alternatives and performance related issues. Specifically, the reconnaissance survey clearly shows the soils overlying the DBG trenches are much softer and wetter than adjacent in situ soils. This situation could lead to performance problems caused by differential settlement and subsidence, and was addressed. In addition, some trees will require removal prior to construction of the cover, since roots and stumps if left in place would eventually decay and lead to subsidence. Holes left as a result of excavating roots and stumps will require careful backfilling to minimize the potential for subsidence or differential settlement. Any in situ soils or other materials brought to the surface as a result of activities associated with the site preparation or cover construction will require sampling, testing, and analysis, prior to disposal.

In light of these conditions, detailed recommendations are offered in this report with regard to the remedial measures proposed for the DBG. The proposed approach will minimize threats to human health and the environment from releases by minimizing infiltration of precipitation, thereby significantly reducing the percolation rate through the cover. The area is relatively small (1/4 to 1/3 acre) as compared to most hazardous waste sites. Therefore, it is expected that the design presented can be readily constructed by a contractor with successful experience in flexible membrane liner (FML) placement.

Quality control of handling and seaming of the FML is expected to be good to excellent, because of the small area and the low slopes specified. The performance of the cover will depend heavily on the contractor achieving the specified limits of unit weight, moisture content and hydraulic conductivity of each soil layer. Test methods for determining hydraulic conductivity of compacted cover materials are provided in the Quality Assurance/Quality Control (QA/QC) USEPA document EPA/600/R-93/182 (USEPA September 1993).

In addition to maintaining quality control during construction, vegetation and cover integrity must be properly maintained after construction. A fair stand of grass (species identified in the Design and Construction Considerations section) should be kept during the growing season and surface depressions or sloughs must be promptly repaired. The success of the construction is also weather dependent and therefore construction should take place during the dry season. If quality control is met, the proposed design should perform favorably for 50 years or longer, as indicated by the hydrologic analysis using the Hydrologic Evaluation Landfill Performance (HELP) model (Schroeder et al. 1994) presented later in this report.

Plan and Profile View of the Proposed DBG Cover

Cross-sectional views of the proposed cover components are illustrated by Figure 6. Each layer is sloped at five percent dipping away from the cover's centerline. The layers are listed from the waste upward to the ground surface: (1) sacrificial fill, a nominal 4 in. thick; (2) non-woven geotextile cushion; (3) geosynthetic clay layer (GCL), approximately 0.25 in. thick; (4) textured flexible geomembrane liner (FML), 60 mil thick; (5) sand drainage layer, a minimum of 6 in. thick; (6) non-woven geotextile filter fabric; (7) biotic barrier, a minimum of 6 in. thick; (8) non-woven geotextile filter fabric; (9) topsoil, a minimum thickness of 27 in. The areal extent of the cover (Figure 5) is between 1/4 to 1/3 acre with a total width of approximately 45 ft and length of approximately 330 ft. According to the reconnaissance surveys, approximately 133 trees may have to be removed prior to construction. A list of trees, by location and size, is provided by Table 2.

Compatibility of the waste with the geosynthetic materials is not known because the waste dyes have not been identified. The cover design is intended to keep the waste isolated from the geosynthetics, by constructing a layer of fill directly above the waste trench, overlain by a geosynthetic clay liner. The waste would have to travel upgradient to move through the fill and the GCL to reach the FML. It seems unlikely that contact between the FML and waste will occur. Even if incidental contact occurs, the specified materials are more resistant to chemical exposure than other available materials.

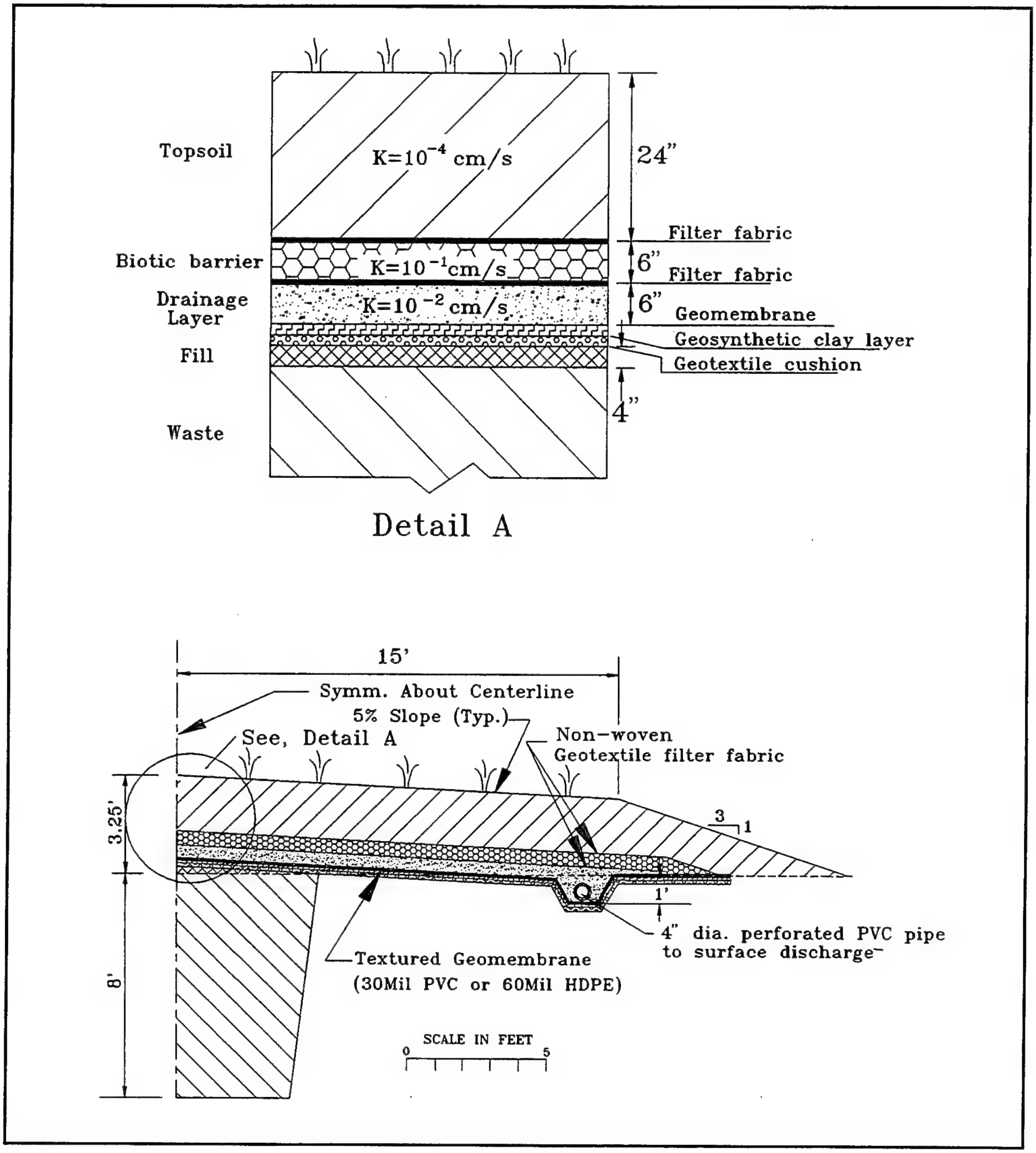

Figure 6. Section view of cover design for DBG Crane, Indiana

Hydrologic Analysis Using the HELP Model

The HELP computer program is a quasi-two-dimensional hydrologic model of water movement across, into, through, and out of landfills. The model accepts weather, soil, and design data and uses solution techniques that account for the effects of surface storage, snowmelt, runoff, infiltration, evapotranspiration, vegetative growth, soil moisture storage, lateral subsurface drainage, leachate recirculation, unsaturated vertical drainage, and leakage through soil, geomembrane or composite liners. Landfill systems consisting of various combinations of vegetation, cover soils, waste cells, lateral drainage layers, low permeability barrier soils, and synthetic geomembrane liners may be modeled. The program was developed to conduct water balance analyses of landfills, cover systems, and solid waste disposal and containment facilities. As such, the model facilitates rapid estimation of the amounts of runoff, evapotranspiration, drainage, leachate collection, and liner leakage that may be expected to result from the operation of a wide variety of landfill designs. The primary purpose of the model is to assist in the comparison of design alternatives as judged by their water balances (Schroeder et al. 1994).

The top portion of Table 3 defines the cover materials by layer number, layer type, thickness, and hydraulic conductivity. The layers are typed by the hydraulic function they perform. Four types of layers are available: vertical percolation layers, lateral drainage layers, barrier soil liners, and geomembrane liners. The topsoil and waste layers are generally vertical percolation layers. Sand layers above liners are typically drainage layers; compacted clay layers and GCL's are typically barrier soil layers. Geomembranes are typed as geomembrane liners. Geotextiles are not considered as layers unless they perform a specific hydraulic function.

Flow in a vertical percolation layer (layer 1) is either downward due to gravity drainage or extracted upward by evapotranspiration. The rate of gravity drainage in a vertical percolation layer is assumed to be a function of the soil moisture storage. Waste layers and layers designed to support vegetation should be designated as vertical percolation layers.

Lateral drainage layers (layers 2 and 3) promote lateral drainage to collection systems. Vertical drainage in a lateral drainage layer is modeled in the same manner as for a percolation layer, but saturated lateral drainage is

Table 3
Fifty-Year Hydrologic Evaluation of Proposed Trench Cover Using the HELP Model[2]

Soil Design and FML Input Data for HELP Model							
Layer No.	**Layer Type**	**Material**	**Thickness (in.)**	**K (ft/day)**	**Pinhole Density (#/acre)**	**Installation Defects (#/acre)**	**Placement Quality**
1	VP	topsoil	27	3.4×10^{-0}			
---	---	filter fabric	---	---	---	---	---
2	LD	cobbles & gravel	6	$3{,}401.4 \times 10^{-0}$			
---	---	filter fabric	---	---	---	---	---
3	LD	sand	6	340.2×10^{-0}			
4[1]	FML	HDPE	0.06	3.4×10^{-8}	1	2	2
5	BS	GCL	0.25	3.4×0^{-4}			

Hydrologic Results from HELP Model 50 Year Simulation				
	Average Annual Totals		**Average Annual Peak Daily Values**	
	(in.)	**(cu ft)**	**(in.)**	**(cu ft)**
Precipitation	47.5	43,158	4.3	3,960
Runoff	7.9	7,200	2.5	2,330
Evapotranspiration	30.7	27,880	---	
Lateral drainage collected from layer 3	8.9	8,030	0.8	705
Average head on top of layer 4	0.13	---	3.8 (max. 5.0)	---
Leakage thru layer 5	0.00004	0.032	0.000002	.002

[1] RCRA restricts the head on FML's to be not greater than 12 in.
[2] LD = lateral drainage; VP = vertical percolation; BS = barrier soil; FML = flexible membrane liner.

allowed. A lateral drainage layer may be underlain only by another lateral drainage layer or a liner.

Barrier soil layers (layer 5) are intended to restrict vertical flow. These layers should have hydraulic conductivities substantially lower than those of the other types of layers, typically below 3.4×10^{-2} ft/day. The program allows only downward flow in barrier soil layers. Thus, any water moving into a barrier soil layer will eventually percolate through it. The leakage (percolation) rate depends upon the depth of water-saturated soil (head) above the base of the layer, the thickness of the layer and the saturated hydraulic conductivity of the barrier soil. Leakage occurs whenever the moisture content of the layer above the barrier soil layer is greater than the field capacity of that layer. The program assumes that a barrier soil is permanently saturated and that its

properties do not change with time. (This is an important, key assumption, and requires care in design construction to ensure it is met.)

Geomembrane liners (layer 4) are layers of nearly impermeable material that restrict significant leakage to small areas around defects. Leakage rate is computed from three sources: vapor diffusion, manufacturing flaws (pinholes) and installation defects (punctures, cracks, tears, and bad seams). Leakage by vapor diffusion is computed across the entire area of the liner as a function of the head on the surface of the liner, the thickness of the geomembrane and its vapor diffusivity. Leakage through pinholes and installation defects is computed in two steps. First, the area of soil or material contributing to leakage is computed as a function of head on the liner, size of the hole, and the saturated hydraulic conductivity of the soils or materials adjacent to the geomembrane liner. Second, the rate of leakage in the wetted area is computed as a function of the head, thickness of soil and membrane and the saturated hydraulic conductivity of the soils or materials adjacent to the geomembrane liner (Schroeder 1994). Table 3 includes the input parameters which define the proposed geomembrane (layer 4). The values entered for pinhole density, installation defects, and placement quality are favorable, but reasonable (i.e., a small number of defects are expected) considering the small areal extent of the geomembrane (1/4 to 1/3 acre) and the expected high quality control during placement. For example, the value of 2 (entered for placement quality) represents excellent contact between FML and the barrier soil layer (in this case the GCL). Excellent placement of the geomembrane over the GCL, will result in lower transmissivity of leaks along the FML and GCL interface, and ultimately, in less leakage into the waste layer.

A fifty year simulation was conducted using the HELP model. Twenty-three years (1971-1993) of past precipitation and temperature data (NOAA 1974) were entered into the model, in addition to the geologic and synthetic properties of the landfill cover (Table 3). The HELP model predicted the next fifty years of hydrologic conditions and computed the amount of runoff, storage, evapotranspiration, and percolation into and out of the layered sequence (geosynthetic cover). The hydrologic conditions included precipitation, temperature changes, solar radiation, and wind velocities. Solar radiation and wind velocity data were not available in the NOAA records and therefore were generated by HELP.

The objective of the proposed cover design is to direct water away from the waste area and to inhibit infiltration into the waste layer. The HELP model estimates the average annual head above the FML and the average annual leakage through the underlying GCL. The HELP model also provides the peak daily values over the total time selected (50 years) for comparison to EPA regulations.

The bottom of Table 3 shows the results of water infiltration and runoff as a consequence of the weather data. The results of the HELP model indicate the objective of the cover design will be met. The estimated average annual leakage, through the FML and the GCL, to the waste below, is essentially zero (0.00004 cu ft). From the average value, over a period of 50 years, a computed total value of 0.002 cu ft will flow into the waste layer. The peak daily

value of leakage through the GCL is also essentially zero (0.000004 cu ft). The average annual head on the FML as computed by the HELP model is 0.128 in. The peak daily average head on the FML is 3.8 in. for years one through 50. The maximum peak daily head is 5.0 in., occurring once in fifty years. Resource Conservation and Recovery Act (RCRA) regulations limit the one time maximum permissible head on the FML to less than 12 in. Therefore, the HELP model clearly indicates acceptable cover performance, assuming cover integrity is maintained, and quality control is satisfactory during construction.

The HELP model does not consider water behavior beyond the lowest FML or barrier soil layer. It is assumed therefore, that any leakage through the GCL (layer 5) will seep into the underlying layer (fill and waste) and has the potential to flow out. However, the behavior of existing water within the trenches is correlated to a one dimensional consolidation analysis presented later in this report.

Design and Construction Considerations, Including Performance Specifications

A general sequence for construction of the cover has been included. This sequence and the layer material performance specifications in Table 4 have been discussed with the NSWCC staff and the Remedial Action Contractor (RAC) to assist in preparation of project specifications.

Table 4
Design and Performance Specifications for Cover Materials

Layer	Layer Thickness (in.)	Lift Thickness (in.)	Dry Unit Weight γ_d (pcf)	Moisture Content w (percent)	Hydraulic Conductivity K (ft/day)
Topsoil (native)	27	12	90% γ_d max (Std Proctor-ASTM D 698)	w_{opt} to w_{opt} + 3%	3.4×10^{-0}
Non-woven geotextile	---	---	---	---	---
Biotic barrier (cobbles and gravel)	6	6	---	---	$3{,}401.4 \times 10^{-0}$
Non-woven geotextile	---	---	---	---	---
Sand drainage layer (SW or SP)	6	6	---	dry	340.2×10^{-0}
Textured geomembrane	0.06	---	---	---	3.4×10^{-8}
GCL	0.25	---	---	---	3.4×10^{-4}
Non woven geotextile cushion	---	---	---	---	---
Sacrificial fill layer	4	4	---	---	---

The total cost of the cover materials was estimated to be approximately $44,000. Costs are presented in Appendix B. Local cost for topsoil, gravel, and sand will vary; hence a better estimate can be developed by the RAC with the given volumes.

Construction sequence (refer to Figures 5 and 6)

a. Conduct topographic survey to 1-ft contour level with wells, surface features, trench boundaries and trench centerline located, including trees and access road.

b. Mark and remove all trees which are 50 ft or less from centerline of trench axes and/or 50 ft from the ends of the system of trenches. Grind all tree stumps larger than 8 in. diameter and remove. This cleared area will provide approximately 15 to 20 ft of space between the toe of the trench cover and the trees in all directions, which should be sufficient for access roads, drainage/collection ditches, mowing equipment, etc.

c. Mow close to ground surface during dry period and remove all clippings, using low ground pressure equipment and hand labor, as necessary to minimize potential for rutting area above and adjacent to trenches.

d. Grade area to provide slope of 5 percent from trench centerline 50 ft to edge in both directions. Material excavated from edge of cap area that is free of vegetation or woody debris may be used as sacrificial fill above trench area, to balance cut and fill operations. A nominal lift of up to 4 in. of fill may be placed above trench. Fill should be proof-rolled with light compactive effort to avoid rutting area above trenches.

e. Lightly scarify (disk) area to be covered by cap, taking precautions to minimize potential for rutting above trenches and for bringing potentially contaminated materials to the surface. Light equipment and/or manual labor will be required to achieve this task. It is considered preferable to omit scarification than to risk rutting or excessive surface disturbance, if scarification cannot be safely accomplished.

f. Construct drainage collection trenches, approximately 1 ft deep by 2 ft wide, sloped 1 percent longitudinally to surface discharge point. The use of multiple outlet points for collection pipes is permissible. Construct collection trenches approximately 13 ft from the centerline of trench cover and parallel to the centerline.

g. Install non-woven polypropylene geotextile cushion to 2 ft beyond end of biotic layer (see step n).

h. Install geosynthetic clay liner (GCL) above geotextile to 2 ft beyond end of biotic layer.

i. Install textured 60-mil HDPE geomembrane above GCL to 2 ft beyond end of biotic layer.

j. Install non-woven filter fabric in drainage trench, lapped over trench sides.

k. Install one 4 in. perforated PVC pipe, covered with clean gravel. Wrap with non-woven polypropylene filter fabric in each drainage trench, overlapping the ends by 2 ft.

l. Cover pipe gravel and filter fabric in drainage trench with sand. Place sand drainage layer. See Appendix E for potential sources.

m. Install one layer of non-woven polypropylene geotextile filter fabric above sand.

n. Construct 6 in. biotic barrier layer (cobbles and gravel). See Appendix E for potential sources.

o. Install one layer of non-woven polypropylene geotextile filter fabric over biotic barrier layer.

p. Construct topsoil layer in 12 in. or thinner compacted lifts to specified moisture and unit weight to achieve overall layer thickness of 27 in. or greater. Ensure specified top slope of 5 percent.

q. Seed and mulch area according to appropriate standards and methods for humid areas. See Appendix D for recommendations.

Note: Steps a through q will result in an eight-layer geocomposite cover beginning with a non-woven geotextile cushion, overlain by a GCL, overlain by a textured geomembrane, overlain by a 6 in. sand drainage layer, overlain by a 6 in. biotic barrier with the biotic barrier sandwiched between non-woven geotextile layers, and finally overlain by 27 in. of topsoil. The overall cap thickness will be a nominal 43 in., including the initial 4 in. of sacrificial fill.

Analysis of Settlement/ Consolidation and Effluent Volumes

Settlements were estimated above the trenches and outside the trench boundaries, that would be expected to occur as a result of the imposed cover loads. A one-dimensional analysis, based on Terzaghi's theory of consolidation, was used (Casagrande's Method, (Peck et al. 1974)). Consolidation test data were not available on the materials within or adjacent to the trenches, since sampling was not conducted for this purpose. Rather, the existing logs of representative borings made in the vicinity of the DBG (Dunbar 1982) and respective laboratory soils tests (Table 1) were used to estimate soil conditions adjacent to the trenches. Visual, non-disruptive, surface inspection provided the basis for evaluating soil conditions on the surface of the trenches.

Consolidation data were obtained from the WES soils laboratory files on soils that were reasonably similar to the DBG soils (inside and outside of the trenches), with respect to classification, consistency, plasticity, and natural water content. These data were then used to model the soils within and adjacent to the waste trenches. Specifically, the soil within the trenches was modeled as a saturated, very soft plastic clay, with a dry density of 53 lb/ft^3 and natural moisture content of 79 percent. The soil adjacent to the trenches was modeled as a medium stiff to stiff, silty clay, with a dry density of 88 lb/ft^3 and a natural moisture content of 34 percent. The portions of the consolidation curves between the original effective stresses at mid depth of the consolidating layers and the original effective stresses plus stresses imposed by the cover materials, were used to predict settlements.

Total and Differential Settlements

The maximum estimated settlements based on this analysis were 6.0 in. within the trenches and 1.5 in. outside the trenches, for a differential settlement of 4.5 in. This analysis is considered to be conservative (i.e., the analysis predicts settlements that are larger than should be expected) for the following reasons.

a. The waste trenches are quite narrow (10 ft), therefore some of the loads imposed by the cover on the trench materials would be carried by the stiffer soils adjacent to the trenches. This redistribution of imposed stress occurs as a result of arching in the cover materials, which are stiffer than the softer soils in the trenches. Extensive documented evidence exists to support this arching effect.

b. The depth of the consolidating layer, i.e., the depth of materials in the trench was assumed to be 8 ft, and the entire profile was assumed to be very soft. In fact, 4 shallow borings made in November 1994 adjacent to the trenches encountered weathered rock at 6.5 to 8.0 ft (Appendix A). Further, the consistency of the soils in the trenches varies from medium in the slightly drier crust material in the upper 1 ft, to very soft assumed consistency below this depth. It is reasonable to assume that the materials near the interface with the weathered rock are stiffer than those in the middle portion of the trench depth, as some self-weight consolidation has occurred in the 30 plus years since waste disposal ceased in 1964.

In light of these facts, the previously stated estimate of settlement (6.0 in.) within the trenches should be considered as an upper bound estimate. The settlement outside the trenches (1.5 in.) may be slightly underestimated, as the arching transfers additional stresses to the materials near the trench boundaries. Therefore, arching action would result in somewhat lower differential settlements. The settlement analysis was repeated to account for arching, by assuming that the loads imposed on the materials inside the trenches was reduced by 30 percent. All other assumptions remained constant, i.e., depth of consolidating layer, consistency, density, water contents, and loads imposed outside the trenches. Therefore, this analysis, while predicting more realistic settlement values, is still somewhat conservative. The estimated settlements from this analysis were 4.6 in. inside the trenches and 1.5 in. (no change) outside the trenches, for a calculated differential settlement of 3.1 in. The total volume of effluent produced from the 3 trenches by this settlement would be 4,300 gal, assuming the trenches are fully saturated.

Time Rate of Consolidation

These estimated settlements and effluent will not occur instantaneously at the end of construction, but rather progress with time, depending on the nature of the consolidating layers. Therefore, the time-rate of consolidation was analyzed to allow reasonable estimates of the settlements and effluent production expected over time. These estimates should prove useful in the collection and evaluation of performance monitoring data, as discussed in subsequent paragraphs. This analysis indicated that total settlements due to 90 percent primary consolidation will occur within 4-1/2 years after the end of construction, while approximately 50 percent of total settlements (and effluent production) will occur within 1 year. These and other percentage consolidation values are shown in Table 5 and plotted on Figure 7 for both cases (arching and no arching). The differential settlements at the end of 1 year (at approximately

Table 5
Percent Consolidation of Trench Waste at Time T_x - Terzaghi's One-Dimensional Analysis

U Percent Consolidation	Tv Terzaghi's Time Factor	t_x Time (days)	Settlement of Trench Waste Material	
			S_1 (in.) 0.182 tsf Effective Stress	S_2 (in.) 0.127 tsf Effective Stress
10	0.008	15.5	0.6	0.5
20	0.031	60	1.2	0.9
30	0.071	137	1.8	1.4
40	0.126	244	2.4	1.8
50	0.197	382	3.0	2.3
60	0.287	556	3.6	2.7
70	0.403	781	4.2	3.2
80	0.567	1,099	4.8	3.6
90	0.848	1,645	5.4	4.1
95	∞			

Note: S_2 is reduced settlement due to arching effects of the compacted cover materials day.

$H = 8$ ft
$C_v = 0.033$ ft²/day
$$t_x = \frac{T(H)^2}{C_v}$$

50 percent consolidation) should be less than or equal to 2 in. when arching effects are taken into consideration. At the end of primary consolidation (4-1/2 years), considering arching effects, the differential settlement should be less than or equal to 3 in.

The interim cover has been designed to accommodate the upper bound estimates of settlements while maintaining satisfactory performance. During the period of primary consolidation and after, minor settlement troughs, surface sloughs, or other minor distress may occur periodically and should be promptly repaired. Major cracking of the cover, or loss of function of the drainage layer or low-permeability barriers are not expected. As satisfactory performance is documented through regular monitoring and evaluation, decisions can be made with a sound, rational basis for final closure.

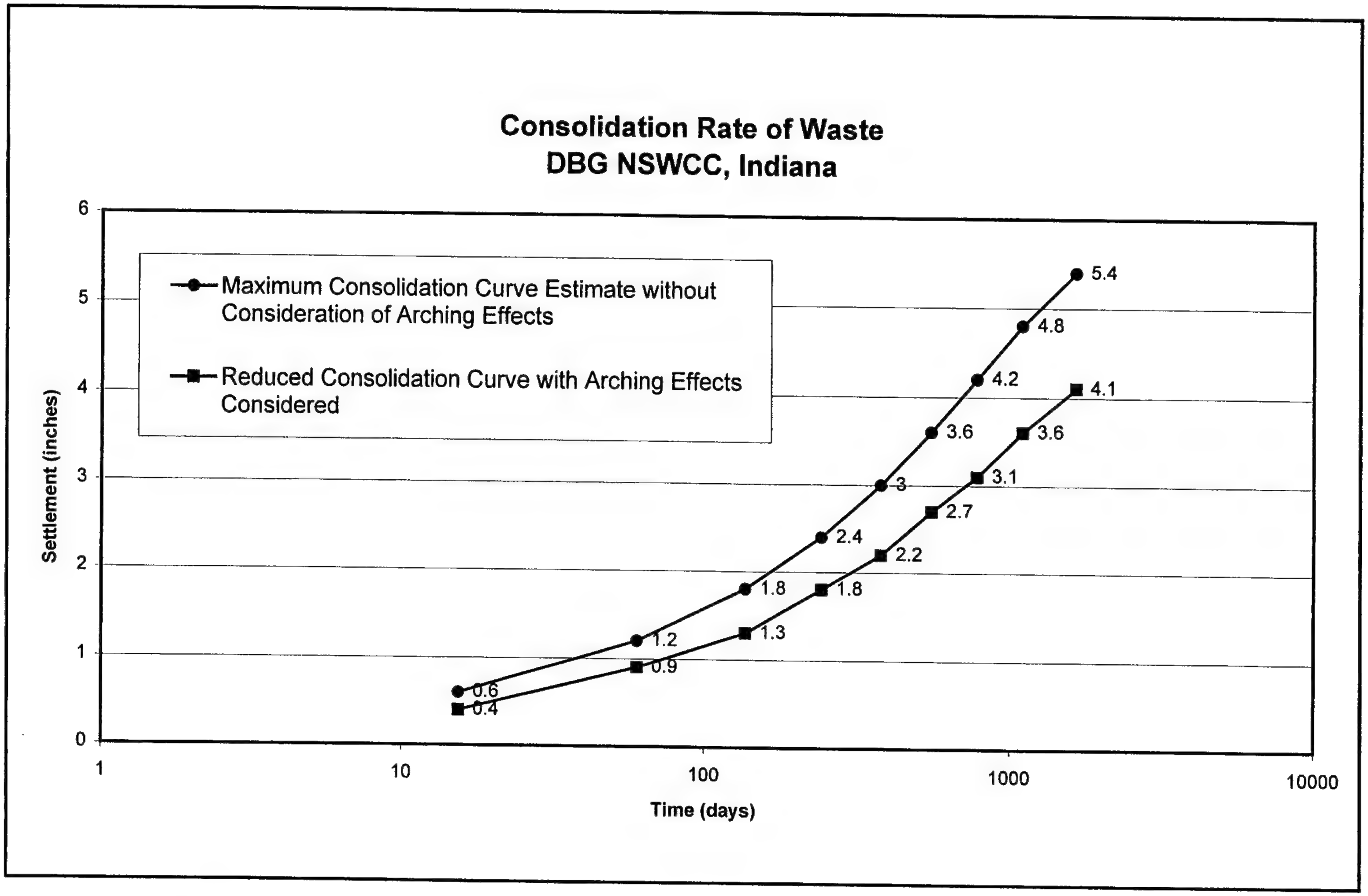

Figure 7. Consolidation curves for trench waste at DBG Crane, Indiana

Performance Monitoring

The primary objectives in performance monitoring are to ensure that the waste cover is functioning as intended, i.e., that it provides protection of the environment and humans from exposure to unacceptable levels of risk from contaminants. To ensure adequate protection is being achieved, it is recommended that groundwater and physical behavior of the cover materials be regularly monitored as detailed below.

Groundwater Monitoring

Groundwater is being monitored by a series of wells in the vicinity of the DBG. This network of monitoring wells was carefully laid out and installed and the wells have been periodically read. To date, no apparent dye-related contaminants have been detected. It is recommended that static water levels of these wells continue to be monitored and that chemical analyses be performed during and after cover construction. Static water level readings should be made on a monthly basis for the first year after construction. Samples should be obtained and analyzed chemically on a quarterly basis for 1 year after construction. Analysis of the data collected during this period would form the basis for longer term groundwater monitoring plans, including frequency of measurements and whether additional wells are needed. Additional wells are not recommended at this time.

Cover Settlement Monitoring

Excessive cover settlement or subsidence could adversely impact isolation of wastes from the environment. Large settlements could cause cracking or distress of the cover, and allow increased infiltration of water through the cover and into the waste filled trenches. Large differential settlements could result in failure of the drainage layer to function properly, further exacerbating infiltration. Therefore, it is important to design the cover to accommodate expected settlements, and to monitor settlements to ensure that allowable values are not exceeded. Estimated settlements have been addressed previously in this report. The interim cover has been designed to accommodate this range of

settlements without distress or loss of function of the drainage layer or the low-permeability layers.

It is recommended that surface settlement points be established at 10 ft spacing along the centerline of the trenches for the full length of the cover and that 2 rows of settlement points be established, parallel to and 10 ft from the centerline at 20 ft spacing for the full length of the cover resulting in three rows of settlement points on top of the completed cover. It is recommended that all settlement points be monitored on a monthly basis for the first year after construction and measurements be analyzed against predicted settlements as an early indicator of cover performance and potential distress. Furthermore, any small depressions or sloughs that are measured or visually observed should be documented and promptly repaired.

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Appendix A Geologic Logs of Split Spoon Borings at DBG - November 1994

DRILLING LOG | DIVISION [illegible] | INSTALLATION [illegible] | SHEET OF SHEETS

1. PROJECT: DYEBURIAL TRENCH	10. SIZE AND TYPE OF BIT: 3 3/4 AUGER
2. LOCATION (Coordinates or Station): ONE FT WEST OF STAKE 1	11. DATUM FOR ELEVATION SHOWN (TBM or MSL):
3. DRILLING AGENCY: WES	12. MANUFACTURER'S DESIGNATION OF DRILL: LONGYEAR
4. HOLE NO. (As shown on drawing title and file number): DBG #1	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED 8; UNDISTURBED
5. NAME OF DRILLER: E. BROWN	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE: ☒ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
7. THICKNESS OF OVERBURDEN	16. DATE HOLE: STARTED 25 NOV 94; COMPLETED 25 NOV 94
8. DEPTH DRILLED INTO ROCK: 0	17. ELEVATION TOP OF HOLE
9. TOTAL DEPTH OF HOLE	18. TOTAL CORE RECOVERY FOR BORING %
	19. SIGNATURE OF INSPECTOR: [signature]

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
Blow cts						
	0					
3			clay. silty dk brown top 0.8 ft — tan 0.8-1.5 OH roots, black specs,		S1	
5		CL	mod. stiff. sl. moist.			
	1					
6					S2	
			1.5-2.0 brown			
4			silty clay, mod. soft. sl. moist. roots, black specs		S3	
	2					
8			2.0-3.0 tan clayey silt mottled w/ white sand lenses,			
9			mod. stiff; sl. moist - dry lo. plastic.		S4	
	3					
9			3.0-4.5 tan to lt. gray clayey silt, w/ some white sand/lenses, mottled			
14			some black specs			
	4	ML	sl. moist, mod. stiff		S5	
15						
			4.5-6.0 lt. gray clayey silt			
7			mod. stiff to stiff			
	5		sl. moist mottled tan —		S6	
12			tan/orange. low plastic.			
17			6.0-7.5 clayey silt, lt tan/gray mottled orange/white lenses of silt/sandstone			
	6					
13			probably v. weathered rock			
			at 6.3, v. stiff - sl. moist - dry			
13						
	7					
18			7.0-8.8 mottled lt gray - tan/orange silt. clayey. v. stiff - sl. moist. dry			S7
7						
18			siltstone at top of rock			S8
	8		top of Rock			
50/3			boh 8.3			

A2

ENG FORM 1836 PREVIOUS EDITIONS ARE OBSOLETE. | PROJECT | HOLE NO.

DRILLING LOG | CRANE | SHEET OF SHEETS

1. PROJECT: DYEBURIAL TRENCH
2. LOCATION (Coordinates or Station): 5 ft to West of stake
3. DRILLING AGENCY: WES
4. HOLE NO. (As shown on drawing title and file number): DBG #2
5. NAME OF DRILLER: E. BROWN
6. DIRECTION OF HOLE: ☒ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN
8. DEPTH DRILLED INTO ROCK: 0
9. TOTAL DEPTH OF HOLE: 7.8
10. SIZE AND TYPE OF BIT: 3 1/4 AUGER
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
12. MANUFACTURER'S DESIGNATION OF DRILL
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED 6 | UNDISTURBED
14. TOTAL NUMBER CORE BOXES: 0
15. ELEVATION GROUND WATER
16. DATE HOLE: STARTED 25 NOV 94 | COMPLETED 25 NOV 94
17. ELEVATION TOP OF HOLE
18. TOTAL CORE RECOVERY FOR BORING %
19. SIGNATURE OF INSPECTOR: M Eileen Corey

ELEVATION (BLOW) a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
3	0	GC	0–0.5 dk. brown gravelly silty clay to moist,			
4			0.5–1.5 clay, silty roots, mod. stiff			
5	1	CL	tan. sl. moist. some white silt. some orange mottled		S1	
4			1.5–3.0 silty clay/ clayey silt. mottled			
6	2		lt. gray / orange tan mod. stiff. sl. moist.		S2	
12	3		3.0–4.5 silty clay/ clayey silt. mottled tan/white			
7			sl. moist - dry			
11			mod. stiff.		S3	
16	4	ML	4.5–6.0 same as above. except. less moist v. stiff. white silt lense at 4.9'–5.0			
9	5		saa. 6.0–7.5		S4	
12			White silt lense 7.0			
16	6		7.0			
4						
8	7		White weathered siltstone friable / contact at ~ 7.3		S5	
12					S6	
	8		boh 7.8			
	9					

ENG FORM 1836 PREVIOUS EDITIONS ARE OBSOLETE. | PROJECT | HOLE NO. 2

DRILLING LOG	DIVISION	INSTALLATION WES	SHEET 1 OF SHEETS

1. PROJECT: DYE BURIAL TRENCH
2. LOCATION (Coordinates or Station): DYE BURIAL GROUND - at Stake 2
3. DRILLING AGENCY: WES
4. HOLE NO. (As shown on drawing title and file number): DBG 3
5. NAME OF DRILLER: Elastic Brown
6. DIRECTION OF HOLE: [X] VERTICAL [ ] INCLINED ____ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN:
8. DEPTH DRILLED INTO ROCK: 0
9. TOTAL DEPTH OF HOLE: 6.8'
10. SIZE AND TYPE OF BIT: 3 3/4" AUGER
11. DATUM FOR ELEVATION SHOWN (TBM or MSL):
12. MANUFACTURER'S DESIGNATION OF DRILL: LONGYEAR
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED 5 | UNDISTURBED
14. TOTAL NUMBER CORE BOXES —
15. ELEVATION GROUND WATER
16. DATE HOLE: STARTED 25NOV94 | COMPLETED 25NOV94
17. ELEVATION TOP OF HOLE
18. TOTAL CORE RECOVERY FOR BORING %
19. SIGNATURE OF INSPECTOR: M Eileen Glynn

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	0		0-1.5 clay, silty mottled tan/lt. gray small spec. black med. soft. med. plastic			
3						
4						
	1					
5			1.5-3.0 silty clay mottled med. gray/dk gray soft, plastic, roots			Some gravel probably from road -
3	2	CL				
4						
6						
	3		3.0-4.5 silty clay mottled lt and dk gray with orange/iron? specs. mod. soft. mod. plastic			Some gravel probably from road
2						
2						
	4					
5					S3	
			4.5-6.0 med gray soft clay, silty roots. black specs. moist. mod. plastic			
2	5					
4					S4	
5			6.0-6.5 soft, silty clay mottled lt. brown, v. moist. mod. plastic, mod. soft.			med gray
	6					
7					S5	
50/3			BOH			
	7		weathered white siltstone 6.5-6.8			
						sample, gravel

A4 ENG FORM 1836 PREVIOUS EDITIONS ARE OBSOLETE. | PROJECT Dye Burial Trench | HOLE NO. DBG 3

DRILLING LOG | DIVISION WES | INSTALLATION | SHEET 1 OF SHEETS

1. PROJECT: DYE TRENCHES
2. LOCATION (Coordinates or Station): DYE BURIAL GROUND TRENCHES — 5 ft West of Stake 4
3. DRILLING AGENCY: WES
4. HOLE NO. (As shown on drawing title and file number): DBG 4
5. NAME OF DRILLER: Elastic Brown
6. DIRECTION OF HOLE: ☒ VERTICAL ☐ INCLINED ______ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN: 7.4
8. DEPTH DRILLED INTO ROCK: 0
9. TOTAL DEPTH OF HOLE: 7.4
10. SIZE AND TYPE OF BIT: AUGER, 3 1/4"
11. DATUM FOR ELEVATION SHOWN (TBM or MSL):
12. MANUFACTURER'S DESIGNATION OF DRILL: LONG YEAR
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED 8 | UNDISTURBED 8
14. TOTAL NUMBER CORE BOXES: 0
15. ELEVATION GROUND WATER:
16. DATE HOLE: STARTED 25 NOV94 | COMPLETED 25NOV94
17. ELEVATION TOP OF HOLE:
18. TOTAL CORE RECOVERY FOR BORING: %
19. SIGNATURE OF INSPECTOR: M Eileen Glynn

ELEVATION a (blow ct.)	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
2, 2, 2	0 – 1.5	CL	Clay tan, soft moist. Roots in top 3 inches. Black spots - throughout. med. plastic		S1	
2, 4	1.5 – 2.0	CL	1.5 - 2.0 soft, moist clay. med. brown mottled . tan and brown, w/ black spec.		S2	
9, 4, 8	2.0 – 3.0	CL	2.0 - 3.0 tan clay, stiff mottled lt gray. tan, orange roots thru out.		S3	
15	3.0 – 4.5	CL	3.0 - 4.5 tan sl. stiff. clay roots, mottled lt.gray/tan, med. plastic.		S4	
3, 7	4.5 – 5.0	CL	4.5-5.0 sl. moist tan, mottled lt.gray. sl. plastic silty clay. med. stiff, org.		S5	
10, 7	5.0 – 6.0	ML	5.0 - 6.0 lt. gray clayey silt. - almost dry.		S6	
13, 50/4	7.0 – 7.5		7.0 - 7.5 weathered siltstone. friable sl. moist - dry mottled tan/white some clay.		S7, S8	

Appendix B
Cost Estimate for DBG Cover Materials

Layer	Material	Area (ft^2)	Vol (yd^3)	Material (cost/unit)	Total Cost
1	topsoil	---	1,220	borrow at site~$2/$yd^3$	$2,440
---	geotextile filter	16,500	---	0.30/ft^2	$4,950
2	cobbles and gravel	---	275	$12/$yd^3$	$3,300
---	geotextile filter	16,500	---	$0.30/$ft^2$	$4,950
3	sand	---	306	$5/$yd^3$	$1,530
Drainage PVC pipe around perimeter	perforated PVC pipe 4 in.	760 ft (length)	---	$0.70/ft	$530
Drainage outlet pipe	solid PVC pipe 4 in.	100	---	$1.00/ft	$100
---	gravel around the perimeter PVC pipe	---	28	$12/$yd^3$	$340
---	non-woven geotextile wrapped around PVC pipe and gravel	1,400	---	$0.30/$ft^2$	$420
4	textured HDPE geomembrane	16,500	---	$0.75/$ft^2$	$12,380
5	GCL	16,500	---	$0.40/$ft^2$	$6,600
---	non-woven geotextile cushion	16,500	---	$0.40/$ft^2$	$6,600
Total cover materials					$44,140

Notes:
- Approximate length of trench cover including side slopes equals 330 ft.
- Approximate width of trench cover including side slopes equals 45 ft.
- Bulking and waste factor of 1.25 applied to all volumes.
- Overlap allowance factor of 1.25 applied to all fabrics.
- Cost for topsoil is for placement of material assumed to be available on site. All other cost estimates are for materials purchased.

Appendix C
Recommended Drainage Outlets

In regard to the requirement for velocity dissipation, the following is suggested:

> For slopes less than 2 percent, grade, and seed ditch. For slopes equal to or greater than 2 percent provide 3 in. cobbles for a distance of approximately 10 ft downstream covering the entire width of the ditch.

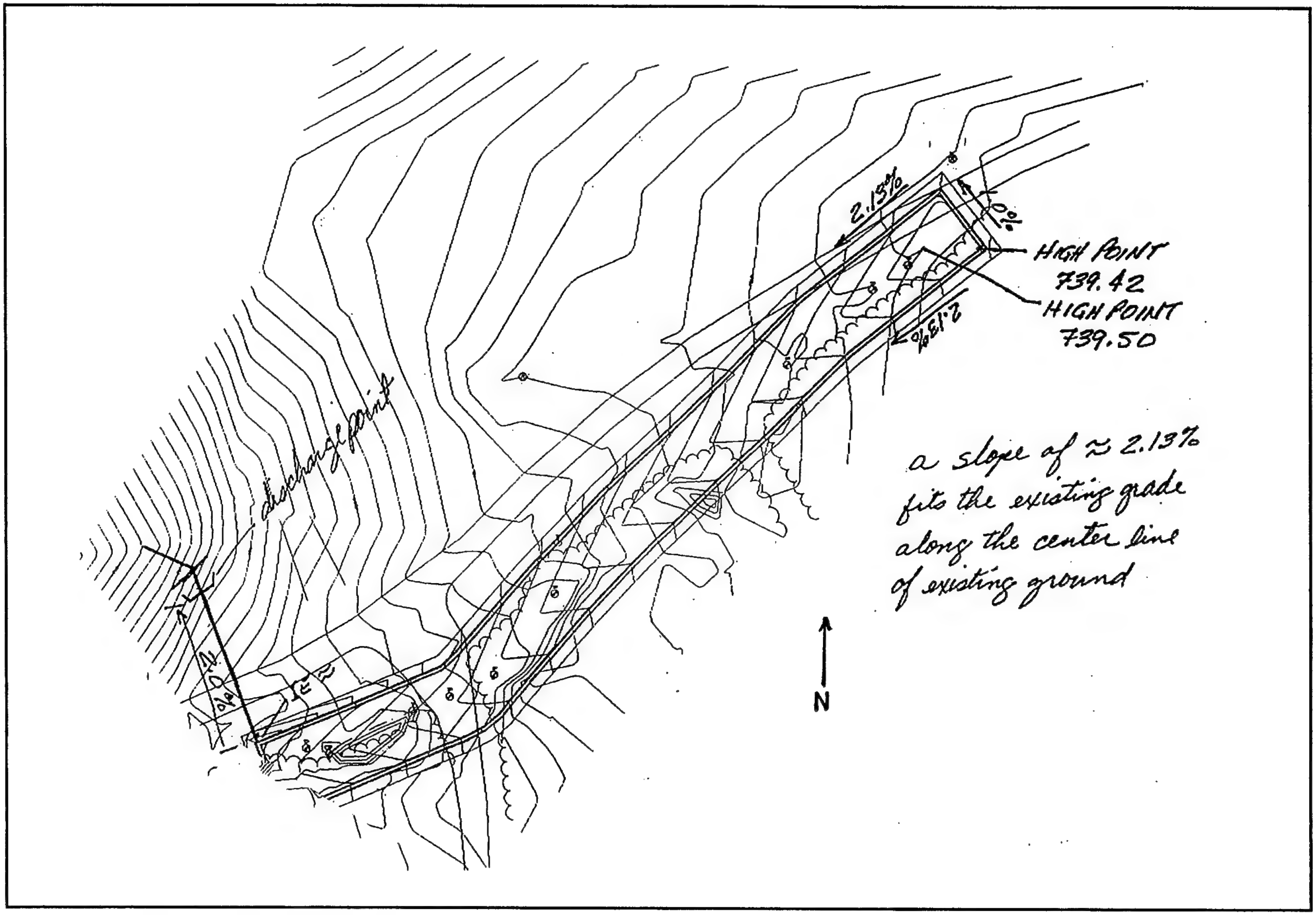

Figure C-1. Recommended drainage outlets

Appendix D
Recommended Seeding and Maintenance for SWMU 02/11 (Provided by Morrison Knudsen)

SECTION 02936
SEEDING

Part I. General

Provide seedbed preparation, fertilizing, seeding, and mulching of all newly graded finished earth surfaces unless indicated otherwise and all areas inside or outside the limits of construction that are disturbed by the subcontractor's operations.

A. Section Includes

1. Seeding, mulching, and fertilizing.
2. Maintenance.

B. Related Sections

1. *Section 01025.* Measurement and Payment.
2. *Section 01305.* Subcontractor Work Plan.
3. *Section 02923.* Landscape grading.
4. *Quality Control Plan.*

C. Definitions

1. *Weeds.* Include Dandelion, Jimsonweed, Quackgrass, Horsetail, Morning Glory, Rush Grass, Mustard, Lambsquarter, Chickweed, Cress, Crabgrass, Canadian Thistle, Nutgrass, Poison Oak, Blackberry, Tansy Ragwort, Bermuda Grass, Johnson

Grass, Poison Ivy, Nut Sedge, Nimble Will, Bindweed, Bent Grass, Wild Garlic, Perennial Sorrel, and Brome Grass.

2. *Stand of turf.* Ninety-five percent ground cover of the established species.

3. *Topsoil.* Fertile, agricultural soil, typical for this locality, capable of sustaining vigorous plant growth.

D. Submittals

1. *Maintenance Data.* Include maintenance instructions including cutting method and maximum grass height, types, application frequency, and recommended coverage of fertilizer.

2. *Documentation* of seed mixture and composition, fertilizer chemical composition, manufacturer's name and indication of conformance to state and federal laws submitted for approval 14 days before use.

3. *Material Safety Data Sheets (MSDS)* shall accompany all chemical compounds and be reviewed per the Special Conditions.

E. Regulatory Requirements

1. Comply with regulatory agencies for fertilizer and herbicide composition.

2. Federal Seed Act Rules and Regulations of the Secretary of Agriculture, January 1985 (DOA FSA).

F. Delivery, Storage, and Protection

1. Protect seed from drying out and from contamination during delivery, on-site storage, and handling.

2. Deliver grass seed mixture in sealed packages bearing the producer's guaranteed analysis for percentages of mixtures, purity, germination, weedseed content, and inert material. The seed shall be labeled in conformance with the Department of Agriculture FSA and applicable state seed laws. Seed in damaged packaging is not acceptable. Wet, moldy, or otherwise damaged seed will be rejected.

3. Deliver fertilizer to the site in original, unopened containers bearing the manufacturer's chemical analysis, name, trade name, trademark, and indication of

conformance to state and federal laws. Instead of containers, fertilizer and lime may be furnished in bulk with a certificate indicating the above information. Containers shall be marked and labeled per 29 CFR 1910.1200.

4. Store seed, lime, and fertilizer in a cool dry location away from contaminants.

5. Do not drop or dump materials from vehicles.

G. Maintenance Service

1. Maintain seeded areas immediately after placement until grass is well established and exhibits a vigorous growing condition for two cuttings.

Part II. Products

A. Seed Suppliers

Not used.

B. Seed

1. *Classification.* The seed shall be State approved consisting of the latest season's crop. Field mixes will be acceptable when the field mix is performed on site in the presence of the contractor.

2. *Composition.* The seed shall consist of a mixture of the following grasses: Kentucky 31 Fescue, Perennial rye, and Kentucky Bluegrass. The mixture shall consist of 50 lb/ac. Kentucky 31 Fescue, 35 lb/ac. Perennial Rye, and 25 lb/ac. Kentucky Bluegrass for a total of 110 lb of seed per acre.

3. *Components.* The pure seed comprising the seed mixture shall have the following properties:

Seed	Minimum Percent Pure Seed	Minimum Percent Germination and Hard Seed	Maximum Percent Weed Seed
Kentucky 31 Fescue	98	85	0.75
Perennial Rye	95	90	0.50
Kentucky Bluegrass	85	80	0.50

C. Top Soil

Top soil shall be as stated in Section 02923, Landscape Grading.

D. Accessories

1. *Fertilizer.* FS O-F-241, Type I, Class 2, free flowing, uniform in composition with nitrogen-phosphorus potash ratio of 12 percent Nitrogen, 12 percent phosphorus, and 12 percent soluble potash. MSDS shall be provided to the contractor for all fertilizer.

2. *Water* shall be suitable for irrigation and free of substances or matter that could inhibit vigorous growth of grass.

3. *Mulch.* Mulch shall consist of marsh hay for lawn areas. The hay shall be of an air dry condition and of proper consistency for placing with commercial mulch blowing equipment. Mulch shall be free from noxious weeds, mold, and other deleterious materials.

4. *Erosion control materials.* The following materials are acceptable for erosion control: net, fiber or excelsior blanket, chemicals, or vegetable based gels. The net may include heavy twisted jute mesh, plastic net, biodegradable paper fabric with knitted yarns, or standard weave burlap. Chemicals may include petroleum oils and resins in solution or high polymer synthetic resin dispersion. The vegetable based gels may include physiologically harmless, without phytotoxic or crop damaging properties, naturally occurring powder hydrophilic additives formulated to provide gels that will form membraned networks of water insoluble polymers within 4 hours after application.

Part III. Execution

A. Placing Topsoil

Placement of topsoil shall be as stated in Section 02923, Landscape Grading.

B. Fertilizing and pH Adjustments

1. The subcontractor shall review the MSDSs and determine the necessary precautions and controls for safe application.

2. Apply fertilizer and pH adjuster according to manufacturer instructions.

3. Incorporate fertilizer and pH adjuster into the soil to a minimum depth of 2 in.

4. Do not apply fertilizer at the same time or with the same machine as will be used to apply seed.

5. Mix thoroughly into upper 2 in. of topsoil.

6. Lightly water to aid the dissipation of fertilizer.

C. Seeding

1. Immediately before seeding, restore soil to the proper grade. Do not seed when the ground is muddy, frozen, snow covered, or in an unsatisfactory condition for seeding. Do not apply seed in excessive winds. If special conditions exist that may warrant a variance in the above seeding conditions, submit a written request to the contracting officer stating the special conditions and a proposed variance.

2. Apply seed within 24 hours after seedbed preparation. Apply at a rate of 110 lb per acre evenly in two intersecting directions. Sow one-half the seed in one direction and sow the remainder at a right angle to the first sowing. Cover the seed to an average depth of 1/2 in. by means of spike-tooth harrow, cultipacker, or other approved device.

3. Do not seed areas more than that which can be mulched on the same day.

4. For the planting season sow seeds from February 1 to May 1 for spring planting and from August 5 to November 30 for all planting.

5. Roll the seeded area with a roller not exceeding 90 lb for each foot of roller width. If the seeding is done with a culipack-type seeder or by hydroseeding, the rolling may be eliminated.

6. Immediately following seeding and compacting, apply the mulch evenly at a rate of 2 tons per acre. Anchor by crimping mulch with a serrated disc or by spraying asphalt emulsion on the mulched surface at 0.02 gallons per square yard. Take precautionary measures to prevent asphalt materials from marking or defacing structures, pavements, utilities, or plants.

7. Apply water with a fine spray immediately after each area has been mulched.

D. Seed Protection

1. Identify seeded areas with stakes and string around the area periphery. Set the string height to 36 in. and space stakes at 72 in.

2. The subcontractor shall implement erosion control methods for topsoil and seeded areas such as hay bales and storm water runoff diversion. The subcontractor shall provide maintenance of erosion control measures until growth of grasses is sufficient to prevent future erosion.

Part IV Quality Control

A. Quality Assurance

1. Provide seed mixture in containers showing percentage of seed mix, year of production, net weight, date of packaging, and location of packaging.

2. Provide fertilizer in containers showing manufacturer name, type, grade, nutrient proportions, year of production, net weight, date, and location of packaging.

3. Turf establishment period will be effect until turf has been mowed three times. Mow turfed area to an average height of 1-1/2 in. when the average height of the grass becomes 2-1/4 in.

4. Final inspection will be made upon written request from the subcontractor at least 10 days before the last day of the turf establishment period. Final acceptance will be based upon a satisfactory stand of turf. Areas that do not have a satisfactory stand of turf shall be replanted at the subcontractor's expense.

5. The contractor shall provide Quality Control field inspections as documented in the Quality Control Plan.

Part V Measurement and Payment

A. Unit Price, Measurement, and Payment

1. *Grasses areas.* By the square yard as described in Section 01025, Measurement and Payment, which

includes preparation of topsoil, mulching, fertilizing, seeding, water, and maintenance to specified mowings.

Appendix E
Source for Sand and Gravel

The sand fill materials will be obtained from the Rogers Group's Green County Plant (if it meets conductivity requirements) which is located near Bloomfield, IN. Also attached is a copy of a test report on the sand as performed by IDOT. If this is not acceptable, search for additional sources nearby.

Point of contact is David Bailey at Greene County Plant.

INDIANA DEPARTMENT OF TRANSPORTATION
DIVISION OF MATERIALS AND TESTS

10-14-94

REPORT ON SAMPLE OF
FINE AGGREGATE
NATURAL SAND PRODUCTION QUALITY

CONTRACT NO.		MATERIAL CODE	2861
LABORATORY NO.	94-7-3434-03494	DATE SAMPLED	04-07-94
SUBMITTED BY	DAZA, PETER		
PURPOSE	QUALITY		
SAMPLED FROM	STOCK OR STOCKPILE		
SAMPLED AT	GREENE CO. SAND & GRAVEL (2613) BLOOMFIELD, IN 47424		
QUANTITY REPRESENTED	23		
SAMPLE MARKING	00200		
SOURCE OF MATERIAL	GREENE CO. SAND & GRAVEL (2613) BLOOMFIELD, IN 47424		
REMARKS	PIT		

*** TEST RESULTS ***

TOTAL WEIGHT OF SAMPLE, GRAMS	533
AMOUNT PASSING 3/8-INCH SIEVE, PCT.------	100.0
AMOUNT PASSING NO.4 SIEVE, PCT.---------	96.1
AMOUNT PASSING NO.8 SIEVE, PCT.---------	82.2
AMOUNT PASSING NO.16 SIEVE, PCT.--------	65.4
AMOUNT PASSING NO.30 SIEVE, PCT.--------	42.6
AMOUNT PASSING NO.50 SIEVE, PCT.--------	12.0
AMOUNT PASSING NO.100 SIEVE, PCT.-------	2.1
AMOUNT PASSING NO.200 SIEVE, PCT.-------	1.1
REMOVAL BY DECANTATION, PCT.------------	.7
ORGANIC IMPURITIES, PLATE--------------	1
FINENESS MODULUS-----------------------	3.00
7-DAY STRENGTH, PCT.-------------------	
ACID INSOLUBLE, PCT.-------------------	70.1
APPARENT SPECIFIC GRAVITY--------------	2.697
BULK SPECIFIC GRAVITY------------------	2.580
WATER ABSORPTION, PCT.-----------------	1.69
S.S. SOUNDNESS LOSS, PCT.--------------	
F & T SOUNDNESS LOSS, PCT.-------------	
NACL BRINE F & T SOUNDNESS LOSS, PCT.---	5.38
AGGREGATE SIZE TESTED 23 NAT. SAND	

REMARKS:
MATERIAL MEETS QUALITY REQUIREMENTS FOR ALL USES OF FINE AGGREGATE.

KRH/ E. STURGEON
COPIES TO: FIELD FILE

CHIEF, DIVISION OF MATERIALS AND TESTS

SOURCE
FIELD OFFICE (3) 8 1/2

DIVISION OF MATERIALS AND TESTS
SUMMARY OF PRODUCTION QUALITY RESULTS

OCTOBER 21, 1994

SOURCE GREENE CO. SAND & GRAVEL 2613
BLOOMFIELD, IN 47424

E3

LAB NUMBER	DATE SAMPLED	SIZE NUMBER	REMARKS	BULK SP.G.	ABS PCT	BRI.	L.A. WEAR PCT	S.S. LOSS PCT	F.T. LOSS PCT	QUAL RTNG
94-7-3434-03494	04-07-94	23 NAT. SAND	PIT	2.580	1.69				5.38*	A5

THIS IS A CATEGORY GS SOURCE. SUBCATEGORY A. SOURCE INACTIVE DATE IS 07-07-96.

SOURCE CURRENTLY NOT PROVIDING COARSE AGGREGATE FOR INDOT.

* 25 CYCLES OF F.T. IN 3% NaCl SOLUTION.

Sound Gary Fell

7/23

THIS REPORT IS NOT INTENDED
TO BE USED FOR ADVERTISING.

CHIEF, DIVISION OF MATERIALS AND TESTS.

REPORT DOCUMENTATION PAGE

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7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
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13. ABSTRACT ***(Maximum 200 words)***

This report describes the primary elements necessary for construction and maintenance of a geosynthetic cover for the Dye Burial Ground, Solid Waste Management Unit 02/11 located at the Naval Surface Warfare Center Crane, Indiana.

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Geosynthetic cover
Naval Surface Warfare Center Crane

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